Unit C: Characteristics of Electricity (Physical Science: Physics)

Chapter 6 - Static electric charges collect on surfaces until given a path to escape

<u>Outcomes</u>

- Demonstrate and analyze characteristics of static electric charges and current electricity, including historical and cultural understandings

6.1 <u>The Characteristics of Static Electric Charges</u>

- Solid materials are charged by the transfer of electrons
    - Rubbing a balloon with your hair does not create electrical charges. All matter has electrical charges they are just normally <u>neutral</u> (equal protons/positive and electrons/negative). The rubbing transfers the electric charges from one object to another this phenomenon is called static electricity the study of static electricity is called <u>electrostatics</u>.

Electric Charge

- There are two types of electrical charges: positive and negative
- If something is positive it has lost electrons if something is negative it has gained electrons. Charging an item by "rubbing" transfers electrons making something electronically charged.

The Law of Electric Charges

- *"like charges repel one another, and unlike charges attract one another"*
- Any charged item will attract a neutral item.

A Model for the Electrical Nature of Matter

- Model of the Atom

There are three ways for something to be electronically charged

1. Friction
2. Contact
3. Induction

Charging by Friction

- Friction or rubbing will cause a transfer or build-up of electrons on an object.
- Friction can remove electrons from an object

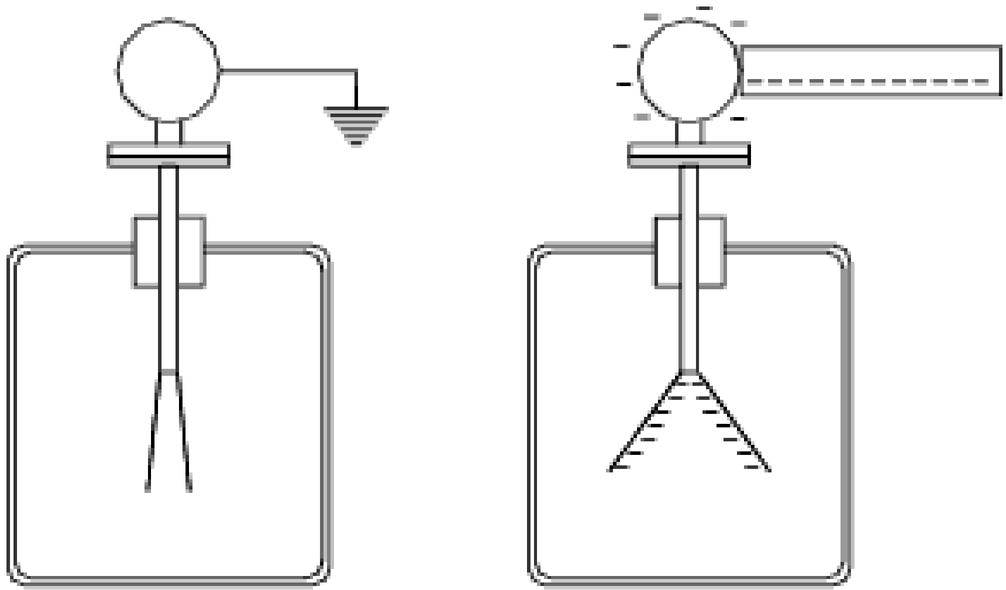
The Electrostatic Series

- A list called the electrostatic series is used to determine the electrical charge of some materials when charged by friction.
  Table 6.2 p. 208

Charging By Contact

- A charged item can transfer its charge by touching a charged or even an uncharged item.

DIAGRAM



Electrostatic conduction

Insulators
An electrical insulator is a substance in which electrons cannot move freely from atom to atom.

Conductors
A conductor is a substance in which electrons can move freely from one atom to another.

Static Electricity and Winter

- Static electricity is much worse in the winter because the air is so dry and dry air is a very good insulator. Water droplets transfer electrons very easily and do not allow large charges to build up.

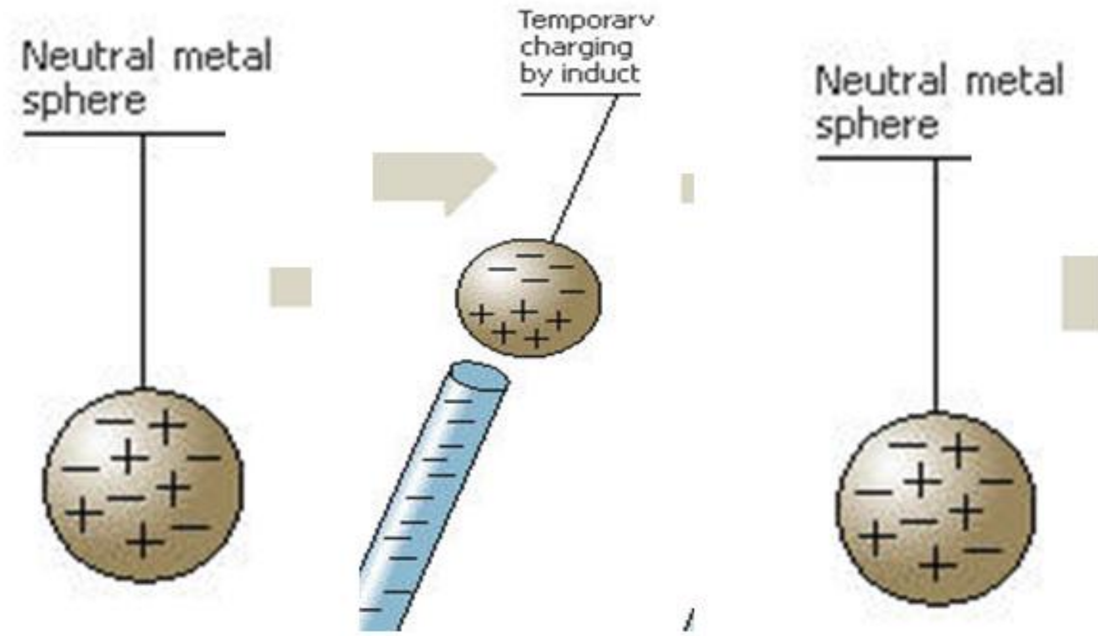
Read Pages 202 - 211
Learning Checkpoint p. 209 # 1 - 5
6.1 Check and Reflect # 1 – 7 (p. 211)

6.2 The Transfer of Static Electric Charges

- In charging by contact, a neutral object gains the same type of charge as the charged object touching it.
- In charging by induction, a neutral object gains the opposite charge as the charged object

DIAGRAM

- Neutral objects attract charged objects



Discharging Electrically Charged Objects

- If a charged object has all of its excess electrical charges removed it is said to be discharged or neutralized.

Grounding

- The simplest way to discharge an object is to connect it to the earth by means of a conductor.

Induction

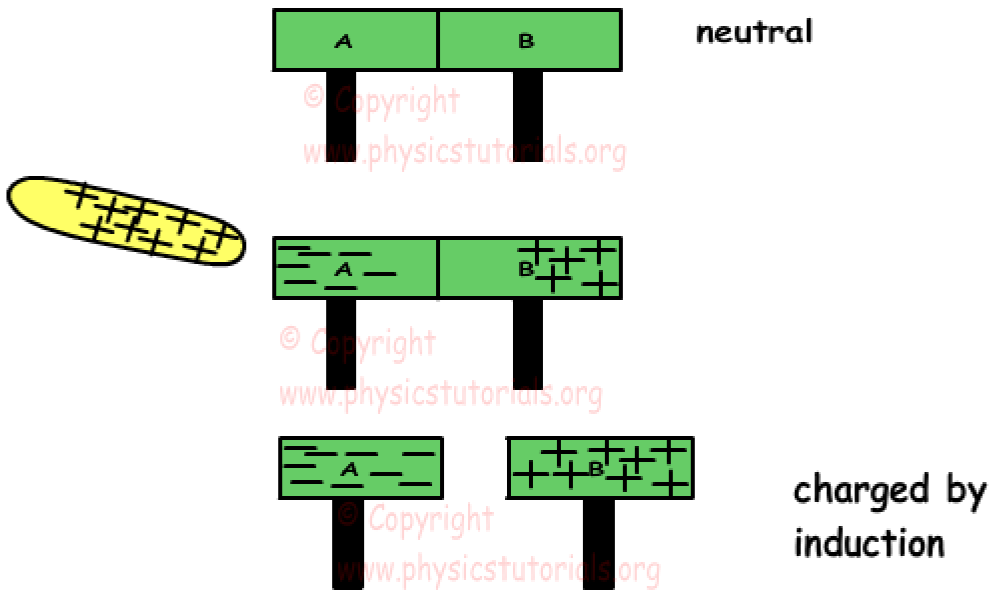
- Induction - something is made to happen without contact

Induced Charge Separation

- A slight shift in position of electrons that produces opposite charges on the two sides of a particle

Charging Conductors by Induction

- It is possible to induce a charge on a conductor and even give it a permanent charge.



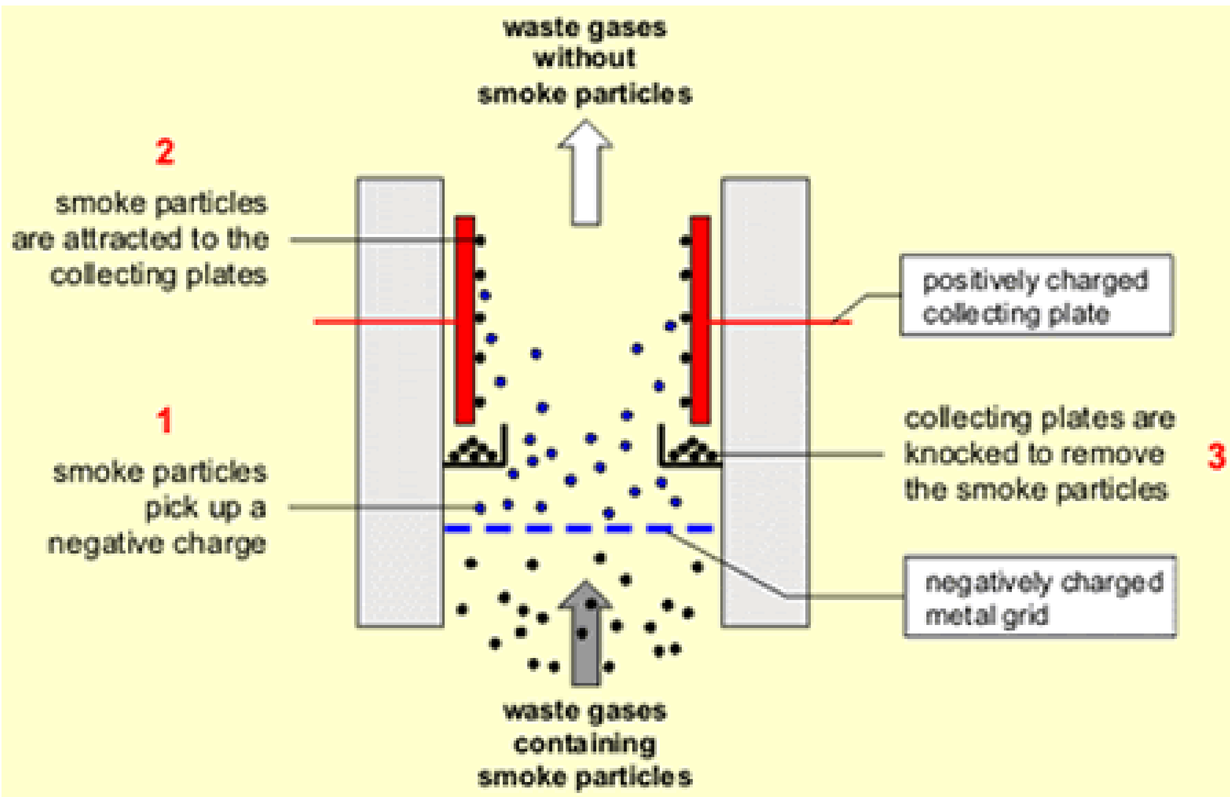
Diagram

Read Pages 213 – 219
6.2 Check and Reflect # 1 – 9 (p. 219)

6.3 <u>Electrostatics in Our Lives</u>

- Some First Nations and Métis peoples have an intimate spiritual understanding of lightning in terms of Thunderbird
- Lightning rods are used to prevent damage to buildings
- Grounding static electric charges can prevent sparks from igniting nearby flammable fuels and damage electronic equipment
- Electrostatic precipitators work by creating charged waste particles and using electrostatic attraction to remove particles

Diagram



Discharge at a Point

- For items that are not attached to the earth like an air plane grounding will not work. Airplanes use a method of discharging at a point of a rod which effectively discharges a charge very quickly.

Diagram

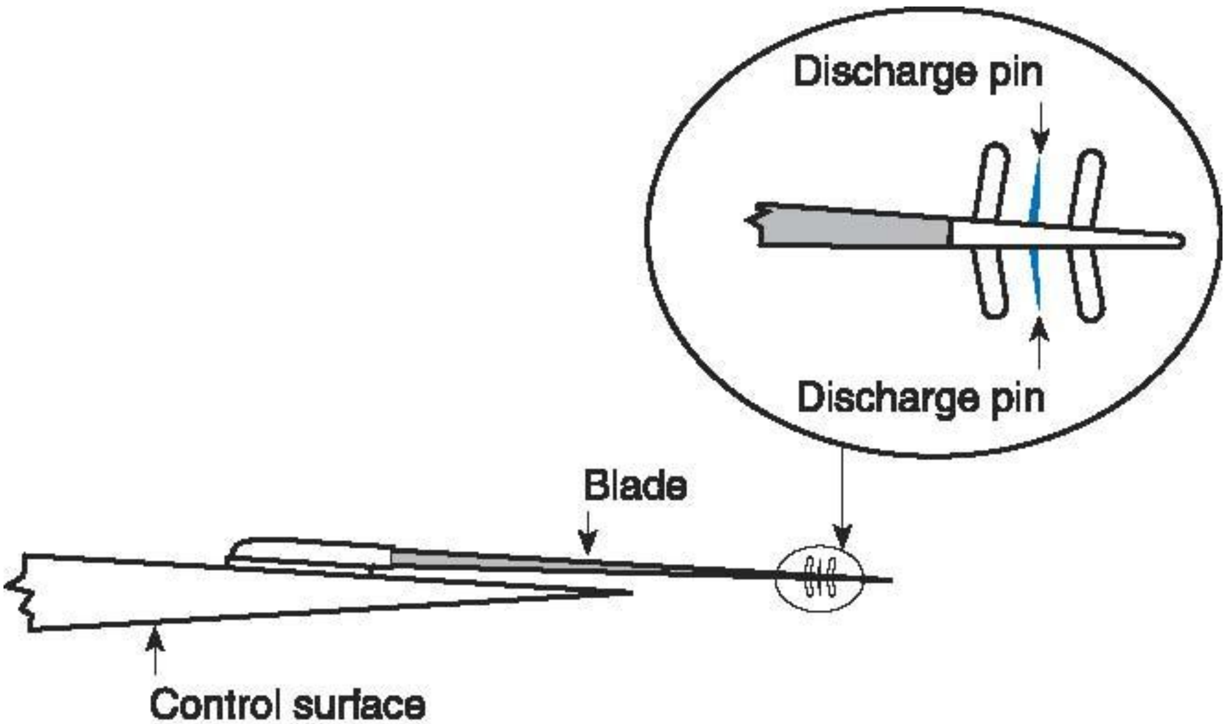


Figure 11-2. *One example of a static wick installed on aircraft control surface to bleed off static charges built up during flight.*

Chapter 7 – Current electrical energy is the flow of electrons in a closed circuit

Outcomes

- Demonstrate and analyze characteristics of static electric charge and current electricity, including historical and cultural understanding
- Analyze the relationships that exist among voltage, current, and resistance in series and parallel circuits

7.1 Voltage, Current, and Resistance

- Static Electricity is the build-up of electrons and the transfer of an electrical charge. The flow or movement of electric charges from one place to another is called electric current.
- Electric current is the rate of movement of electric charge through a conductor.
- The electric current passing through your house is different than static electricity it is flowing through a controlled path called an electric circuit.
- Electric circuits are used to convert electrical energy into other forms of energy we need.

Electric Potential (Voltage)

- Voltage is the difference in electric charge between two points
- The energy each electron has is called the electric potential of the electron. The unit used to measure electric potential is the volt.

Pump Analogy

- Voltage can be compared to the pressure of water in a hose. The higher the pressure, the faster the water will flow through the hose. Similarly, the higher the voltage of the electricity, the faster it will flow from a source of electricity to an end use.

Electric Current

- Electric current is a measure of the rate at which electric charges move past a given point in a circuit. The unit used to measure electric current is ampere.
- Amps can be compared to the volume of water that flows through a hose. The volume of water that flows past a certain point in a specific amount of time can be measured. The rate of the electric current is dependent upon the voltage and resistance. A circuit with high voltage and low resistance will have more amps (greater number of electrons passing through the circuit) than a circuit with low voltage and higher resistance.

Electrical Resistance and Ohm's Law

- The ability to impede the flow of electrons is called electrical resistance. A resistor is used for this purpose. Electrical resistance R is measured in ohms.

Electrochemical Cell

- An electrochemical cell generates electricity by creating an imbalance of charges between terminals

Primary Cells

- Primary cells use materials in a chemical reaction to create electricity.

- A primary wet cell or voltaic cell use two metals (usually copper and zinc) as electrodes and use a liquid (sulphuric acid) as an electrolyte. Copper gives its electrons to zinc and when connected the electrons are allowed to flow.
- Not practical b/c not portable and contains a dangerous electrolyte
- A primary dry cell works in the same manner as a wet cell but it uses a paste as an electrolyte and is sealed.

Secondary Cells

- A secondary cell can be discharged and recharged because it does not use chemicals.
- Models can be mental, mathematical, or a combination. Scientific models can help you communicate your ideas.

Read Pages 234 – 244
Learning Checkpoint p. 242 # 1 - 5
7.1 Check and Reflect # 1 – 14 (p. 244)

7.2 Series Circuits and Parallel Circuits

The Parts of an Electric Circuit

Source of Electrical Energy
- *Cells*
- *Batteries*
- *Generator*
- *Power source (wall outlet)*

Electrical Load
- An electrical load is anything that converts electrical energy into any form of energy we need.
- Resistor – circuit component designed to provide a specific amount of resistance to current flow.
- Lamp/bulb – An electrically energized source of light
- Motor – A device or machine that converts other forms of energy into mechanical energy. Electric to mechanical
- Fuse – A safety device with a metal wire or strip that melts when the current gets too strong, cutting off the flow of the electrical current.
- Circuit Breaker – an additional safety device with a metal that does not melt but instead bends which triggers a mechanism that that turns of the flow of electrical energy
- In a short circuit, the current does not take the intended path back to its source

Electric Circuit Control Device
- Switch – used to open or close a circuit
- Timer and Thermostat
- Ammeter – measures current flow
  - An ammeter is hooked up in series to measure current.
- Voltmeter – measures current pressure
  - A voltmeter is hooked up in parallel to measure voltage

Connectors
- Conducting wires provide a pathway for the electric current to flow.
- Open circuit – the path of the electric current is not complete
- Closed circuit – the path of the electric current is complete

Electric Circuit Diagrams
- A circuit diagram is a model of an electric circuit
- Using the known symbols for some common electrical components a schematic circuit diagram can be used to illustrate a circuit.

Example: Simple Circuit

Four basic parts – load / conducting wire / electrical source / control (switch)

Cells in Series and Parallel

- Cells in series are connected end-to-end and have an additive voltage.

Pump Analogy

- Series Circuit – all components are connected end-to-end, forming a single path for electrons to flow.
- In a series circuit, the current is constant and the voltages across resistors adds up to the total voltage supplied by the energy source
- Adding resistance increases the total resistance and lowers current
- Current is the same throughout the circuit
- The total resistance is the sum of the resistances in the circuit

Example

Three 1.5V cells an ammeter and three resistors (R_1= 4 Ω, R_2= 5 Ω, and R_3=6 Ω) in series

What is the total resistance?

What is the total voltage?

- Cells in parallel are not connected end-to-end and thus do not have an additive voltage instead they are connected beside each other and have twice as many electron doing one cells work.

Pump Analogy

- Parallel Circuit – all components are connected across each other, forming exactly two sets of electrically common points.
- In a parallel circuit, the voltages across loads are constant and the currents on each path add up to the total current leaving the energy source
- Adding resistance decreases the total resistance and increases current
- The more branches there are the smaller the resistance in each branch, the more the total circuit current will be (additive)
- Voltage remains constant and is equal to the source

Example

Three 9 V cells in parallel attached to a switch and an ammeter in series attached to three resistors and a voltmeter in parallel (R_1= 4 Ω, R_2= 5 Ω, and R_3=6 Ω)

What is the total voltage?

Read Pages 248 - 252
7.2 Check and Reflect # 1 – 9 (p. 253)

7.3 <u>Ohm's Law</u>

- Ohms (Ω) measure resistance and can be compared to the diameter measurement of a hose. A smaller diameter hose will allow less water to flow through than a larger diameter hose. Similarly, a thinner wire increases resistance, causing a lesser amount of electricity to be transmitted because it is encountering resistance in the wire. To reduce resistance, certain metals are used to conduct electricity, such as copper, which allows electrons to flow easily.
- When electrons flow through a conductor electrical resistance causes a loss of electrical potential (volts). This loss is referred to as <u>potential</u> <u>difference</u>.

Ohm's Law

- *"the potential difference between two points on a conductor is proportional (directly related) to the electric current flowing through the conductor"*
- We refer to potential difference as voltage drop b/c voltage is lost or "dropped" across a conductor.
- We can calculate voltage drop by:
- Potential difference (voltage drop) = electric current x Electrical Resistance
- V = I x R
- Potential difference (V) is measured in volts (V)
- Electric current (I) is measured in amperes (A)
- Electrical Resistance (R) is measured in ohms (Ω)
- Ohm's Law V = I x R, describes the relationship between voltage, current and resistance

Solving Science Problems Involving Formulas

5 step process

I. <u>Data</u> – record the given and required data
II. <u>Formula</u> – write the required formula
III. <u>Substitute</u> – place the data in the formula
IV. <u>Calculate</u> – do the math (calculator)
V. <u>Statement</u> – write a sentence to paraphrase your work

Example Problem 7.1
A current of 4.0 A flows through a 40 Ω resistor in a circuit. Calculate the voltage.

Example Problem 7.2
A 30 V battery generates a current through a 15 Ω resistor. How much current does the battery generate?

Example Problem 7.3

An electric stove is connected to a 240 V outlet. If the current flowing through the stove in 20 A, what is the resistance of the heating element?

Example

Three 1.5V cells, a switch, an ammeter and three resistors (R_1= 4 Ω, R_2= 5 Ω, and R_3=6 Ω) in series

What is the total resistance?

What is the total voltage?

What is the current for this circuit?

What is the voltage drop for each resistor?

Example

Three 9 V cells in parallel attached to a switch and an ammeter in series attached to three resistors and a voltmeter in parallel (R_1= 4 Ω, R_2= 5 Ω, and R_3=6 Ω)

What is the total voltage?

What is the current through each resistor?

What is the total current?

What is the total circuit resistance?

Practice problems p. 260 – 261 (3)
Read Pages 258 - 264
7.3 Check and Reflect # 1 – 6 (p. 264)
Chapter 7 Review p. 266 – 267 # 1 - 15

Chapter 8 – We can reduce our electrical energy consumption and use renewable energy resources to produce electrical energy

<u>Outcomes</u>

- Assess operating principles, costs, and efficiencies of devices that produce or use electrical energy
- Critique impacts of past, current, and possible future methods of small and large scale electrical energy production and distribution in Saskatchewan

8.1 <u>Renewable and Non-Renewable Energy Resources for Generating Electrical Energy</u>

- <u>Renewable Energy Resources</u> – resources that constantly replenish themselves

E.g. Solar, wind, biomass, hydroelectric, geothermal, tidal

- <u>Non-renewable Energy Resources</u> – resources that cannot be replaced in a reasonable amount of time

E.g. Fossil fuels (oil/coal) and nuclear

- <u>Sustainability</u> – with respect to electrical energy refers to a consideration of social, economic, and environmental aspects of its production and use now and in the future
- We need to move toward sustainability in our resources
- Electrical energy generators transform the energy of motion into electric current

Read Pages 268 - 279
Learning Checkpoint p. 276 # 1 – 3
Learning Checkpoint p. 277 # 1 – 3
8.1 Check and Reflect # 1 – 9 (p. 280)

8.2 <u>Reducing Our Electrical Energy Consumption</u>

Making the Most of Energy Resources

- <u>Input energy</u> – chemical energy used to make electricity
- <u>Output energy</u> – actual electric energy produced
- Efficiency = useful energy output / energy input
- % efficiency = useful energy output / energy input x 100%

Example

Determine the percent efficiency of a bulb that uses 2000 J of electrical energy to produce 400 J of light energy.

Electrical Energy Use in the Home

- Electrical Energy = Electrical Power x time interval
- $E = P \times \Delta t$
- E = kW·h (Electrical energy consumption is usually measured in kilowatt-hours)
- P = kW
- Δt = h

Example

How many kilowatt hours of electrical energy are used in one month by a clothes dryer that has a power rating of 5 kW and is operated for 4.5 h?

<u>Cost</u>

Cost = Electrical Energy (kW·h) x rate (cost per kW·h)

Example

Calculate the cost of the electricity needed to operate a refrigerator/freezer (500 W) for one month if it uses 75 kW·h of energy. The rate charged for electricity is $0.08 / kW·h.

The EnerGuide label shows how much energy an appliance will use in a month of average use
Energy Star appliances are the most efficient appliances in their class

Read Pages 284 - 290
Learning Checkpoint p. 286 # 1
Practice Problems # 1 – 3 p. 287
8.2 Check and Reflect # 1 – 13 (p. 290)

Measuring Electrical Energy

- Energy – the ability to do work
- Electrical energy (E) – energy transferred to any electrical load by moving electric charges
- Electrical energy is measured in joules. A joule is a small amount ~ light a 100 W bulb for 1 / 100th of a second
- Also measured in Watt hour which is 3600 times as much as a joule or kilowatt (1000 W)

Calculating Electrical Energy

- $E = V \times I \times \Delta t$
- where
- E – electrical energy measured in Joules (J) for seconds or Watt hours (W·h) for hours
- V – voltage drop measured in volts (V)
- I – electric current measured in amps (A)
- Δt – time interval measured in seconds or hours

Example

Calculate the energy released from a battery in a flash light that was on for 4.5h with a voltage of 6V and a current of 0.35 amps.

The Rate at Which Energy is Used

- Electrical Power (P) – measure at which electrical energy is used measured in watts
- Electrical power = electrical energy / time interval
- $P = E / \Delta t$

Example

Calculate the power of a toaster that uses 72000 J of energy for 50s

Or

$P = E / \Delta t = V \times I \times \Delta t / \Delta t = V \times I$

Example

Calculate the power of a vacuum cleaner if the operating voltage is 120 V, and the current flowing through it is 7.90 amps

Hand-Out – Electricity Calculations
Chapter 8 Review P. 294 – 295 # 1 – 21
Unit C Review P. 299 – 301 # 1 - 35